Chapter 19
Construction Specifications and Drawings

19-1. Specifications

a. Types of contracts. Construction specifications and drawings for hydroelectric power plant work are used for two different classes of contracts: supply contracts for the purchase of built-to-order equipment from manufacturers; and construction contracts for the building of the powerhouse, switchyard, and related structures. When construction begins before engineering and design of all features are completed, second- and third-stage construction contracts are used to cover the superstructure and/or wiring and installation of machinery and equipment.

b. Selection of contract type. The choice of whether to include electrical equipment procurement within the powerhouse construction scope of responsibility, to directly purchase the required equipment for installation by the contractor (installation only), or to procure design, fabrication, and installation of equipment ("turn-key") is dependent upon a number of factors. These factors include equipment procurement lead times, the complexity of the fabricated equipment, and the need for specialized installation skills. Generally, supply contracts are used to procure equipment with long lead times, equipment with a high degree of complexity, or equipment requiring specialized installation skills and techniques. Typical equipment procured with supply contracts includes generators (turn-key procurement), SCADA systems, high-voltage bus and breakers, generation step-up transformers, and generator- and high-voltage power circuit breakers. Low-voltage switchgear, motor control centers, lighting panels, and cable tray systems are typical of equipment included in a construction scope of supply.

c. Specification preparation. General criteria and policies to be observed in preparing specifications are found in Appendix A of Guide Specification CE-4000. Specifications and plans should be carefully coordinated, and various sections in a given specification (sometimes prepared by different writers) checked to ensure consistency, eliminate conflicts, clearly define limits of payment items, and avoid overlapping payments for any item. Specifications are prepared to accommodate three classes of users of the specifications: the construction and/or manufacturing contractor, the resident engineer, and the field or shop inspector. Specifications for Corps of Engineers civil works projects differ from private sector practices because the specifications and plans must be self-explanatory without amplification about details of the construction or equipment fabrication. Typically, private sector specifications depend on interpretations of the engineering organization designing the project. Private sector specifications are unsuited to the Corps of Engineers' competitive open bidding methods of awarding contracts and performing the work.

19-2. Construction Drawings

a. General. Construction drawings should be complete and based on commercially available equipment and industry-recognized construction and installation techniques. Details of equipment design and installation, wiring, and conduit should be complete to minimize the need for field revision. Discussions in the following paragraphs indicate the type and scope of information that should be included on construction drawings for the various phases of work covered by this chapter.

b. Generators.

(1) Selected or modified drawings from the general arrangement drawings of the powerhouse are generally used to accompany the specifications for purchase of generators. Drawings prepared to accompany guide specifications should indicate various mechanical and electrical interfaces including main leads, piping terminations (e.g., lube oil, cooling water, CO_2, brake air), neutral equipment locations, and excitation system equipment locations.

(2) A plant or main unit one-line diagram should also be included in the procurement drawing set. Equipment centerline should be dimensioned from structure lines. Powerhouse crane hook coverage should be shown on the appropriate procurement drawing set. Other governing or limiting dimensions should be established. Locations and dimensions of openings, sleeves, and interfering equipment should be shown where possible. In cases where dimensions cannot be determined until later, the dimension lines should be drawn in and indication made that the dimension will be added at a later date. Generator procurement drawings may be included in the construction contract set to show the extent of generator erection performed by the generator supplier.

c. Transformers.

(1) Suitable drawings showing the location and general arrangement of the transformers and connecting bus structures and limits of work under the contract

should be included with the transformer procurement specifications.

(2) The drawings should include all features not adequately covered in the specifications affecting the design of the transformers or powerhouse, such as limiting transformer dimensions, rails and other provisions for lifting and moving the transformers, locations of terminal cabinets, surge arresters, chilling sumps and walls between transformers, bushing enclosures for connection to metal-enclosed bus, and location of heat exchangers. Other details include size of oil pipes for Class FOW transformers where the heat exchangers will be installed remotely from the transformers, types and sizes of bushing terminal connectors, and provisions for grounding the neutrals of the high-voltage windings and the transformer tanks.

d. High-voltage system. Construction drawings for this system should show all necessary layouts and details for installation of equipment from the high-voltage bushings of the transformers to the outgoing transmission line interface in the switchyard. These plans should include drawings of the high-voltage leads with details of termination points; switchyard equipment arrangement drawings, including plans, sections, elevations, and details; structure loading diagrams; conduit and grounding plans; and details of lighting and power panels and other miscellaneous equipment. A one-line diagram of the high-voltage system should be prepared, together with control schematics of controlled equipment. Manufacturers' shop drawings are used to a great extent in the actual installation of equipment.

e. Generator-voltage system. Drawings for the generator-voltage system should show sufficient details for purchase of the generator main and neutral leads and associated equipment, and the generator switchgear if included in the supply scope. The drawings should show the general layout, details of arrangement and ratings of equipment, limiting dimensions, termination methods, and a one-line diagram showing items of equipment. If the supply scope includes generator switchgear, control schematics of the controlled equipment should be provided. These drawings are also included with the drawings for the construction contract to show the extent of the installation work. Manufacturers' detail drawings are used for installation of this equipment.

f. Station service systems.

(1) General. Construction drawings for the station service system should consist of the station service one-line diagram and drawings used for purchase of the switchgear and motor control centers, if supply of this equipment is not included in the construction scope of supply.

(2) Station service switchgear.

(a) The station service switchgear drawings should show all information necessary for design of the switchgear and, insofar as possible, the information needed for installation.

(b) The switchgear drawings should indicate the frame size and ampere rating of each breaker, as well as the nameplate designation of each circuit. Wire sizes of outgoing feeders should be provided for correct sizing of circuit breaker lugs. The number and rating of current and potential transformers should be indicated. The preferred layout of indicating and control equipment should be shown.

(c) A one-line diagram should be prepared of the switchgear line-up. Centerline dimensions and preferred routing of any bus included in the switchgear scope of supply should be provided.

(d) Drawings showing the switchgear installation should be prepared with sufficient arrangement flexibility to accommodate variations in dimensions among equipment suppliers. Drawings prepared for the purchase of the switchgear are also included in the contract construction drawings to indicate the scope and complexity of installation and connection. Manufacturers' shop drawings are used for installation of the switchgear.

(3) Motor control centers.

(a) Drawings for motor control centers are similar in scope to the drawings of the switchgear. Motor control centers consist of free-standing cubicles containing combinations of standardized factory subassemblies. The standardized units described in Chapter 7 are preferred.

(b) Outside dimensions of embedded cabinets and locations of conduits for supply and branch circuits should be shown. Motor control center elevations indicating preferred location of starters, control switches, and nameplates should be shown. A one-line diagram with the relative positions of equipment enclosed within the control center, direction of bus runs, the location of bus lugs, and the ratings of all equipment should be provided.

(c) The drawings should contain tabulations of the circuit number, the nameplate designation of the circuit, the expected load, the breaker frame size, the starter size, and the number and size of conductors.

(4) Lighting and power panelboards.

(a) The purchase and installation of lighting and power panels are included in the powerhouse construction contract. Drawings are prepared showing the size of the embedded cabinets, the size of the front covers, bus diagrams, and any pertinent details such as space allocation and wiring diagrams for throw-over switches or remote control switches located in the panels. Tabulations of main bus current ratings, main breaker ratings, location and sizes of main and neutral lugs, and the number and ratings of branch-circuit breakers should be included on the drawings.

(b) Lighting plan circuit designations should be provided on the panel bus diagrams. Panel layouts should provide space for spare and future circuit breakers.

(c) Doors, locks, and details of door openings should be shown. Front covers should overlap the embedded cabinet approximately 1 in. all around. All contactors should be completely separated by barriers from other equipment and from wire gutters.

(d) Buses should also be completely enclosed except at the ends of runs. The necessity for the removable cover over the bus lugs should be considered in locating equipment within the cabinet.

g. Control system. Drawings issued for purchase of switchboards, control panels, and the operator's control console (if required), comprising the plant control system, should include plant and unit one-line diagrams, plant and unit control and protective relay schematics, station service control and protective relay schematics, and associated equipment. Other drawings that should be in the drawing package include switchboard and control console arrangements showing preferred locations of relays, instruments, and control switches. Preparation of wiring diagrams for this equipment should be included in the manufacturer's scope of supply, together with the preparation of terminal connection diagrams to which external plant interconnection details can be added during the shop drawing review process. If a plant energy management system (SCADA) is incorporated in the control system procurement, block diagrams of the system should be incorporated with the procurement drawing set. Control system drawings are also incorporated in the construction drawing set for information as to the extent of the installation work. Actual installation of the control system should be performed in accordance with the manufacturer's approved drawings. Included in the construction set should be drawings providing locating dimensions for control system equipment.

h. Annunciation system. Generally, annunciators are included in the scope of supply for the control switchboards. A drawing of the incoming trouble and alarm points to the annunciators, together with preferred window arrangements and window legends, should be provided. Incoming trouble, alarm, and event points to the plant sequence-of-event recorder (SER), together with a preferred format for printout of recorded events, should be provided on the drawings.

i. Communications system. Drawings that define the scope of facilities that will permit the installation of communication termination equipment should be included in the construction drawing set. The construction contractor will provide the facilities. The communication termination equipment will be furnished and installed by others (see Chapter 10). In addition, a drawing with locations of the plant's code call system should be prepared.

j. Direct current system. The drawing for the purchase of the battery switchboard is similar in scope to those for the equipment discussed in paragraph 19-2*g*. The battery switchboard is generally purchased with the control switchboard. The battery switchboard drawing is included with the construction contract drawings to depict the extent of the work and provide explanatory material.

k. Lighting and receptacle systems.

(1) Lighting drawings on the lighting plan for an area should show all fixture, switch, and receptacle outlets, and all conduits in the walls and ceiling.

(2) Conduits in the ceiling and walls of an area are shown on a floor plan of that area. Conduit in the floor slab for the same area, even though used to feed outlets in the area, should be shown on another plan as in the ceiling for the area below.

(3) Building and room outlines, beams, and openings, should be shown. Rooms should be identified. Normally, it is not necessary to show equipment on lighting drawings. Sections and details should be shown where necessary for clarification. Wiring diagrams and equipment should be detailed in accordance with the drawing legend. All outlets, junction boxes, and conduit

terminations should be located by dimensions and, if necessary, by elevations.

(4) The conduit system should be detailed completely and all sizes and materials noted. Embedded conduit for branch circuits should be limited to ¾- and 1-in. sizes if possible. Conduits serving ceiling fixtures in areas with suspended ceilings should be stubbed out of the concrete. The conduit will be extended to fixture outlet boxes before placing the ceiling suspension system.

(5) Boxes, extension rings, and covers should be suited to the finish of the space in which they are used with appropriate notations or details made on the drawings to ensure the use of the proper materials and fittings. Wall outlet boxes should be sheet metal boxes with suitable extension rings when located above the generator room floor. On turbine room walls, boxes should be cast boxes meeting the requirements of UL 514A.

(6) Complete details should be given for lighting fixture mountings, wiring devices, and device plates. Circuits should be designated by lighting panel number and circuit number and balanced across the lighting panel buses and transformer. The number and sizes of wires in each conduit are indicated by standard hash marks and notes. The system should be color-coded as noted on the typical drawing.

(7) To avoid confusion, local switches and their controlled fixtures should have an individual letter designation to indicate their relation. Fixture, switch, and receptacle types should be designated on the drawings and referred to a schedule giving the fixture type by reference to a catalog product or to a detail drawing. The schedule should also show all mounting fittings.

l. Grounding systems. Grounding system drawings should include all plans, information, and details necessary for the installation of the power plant ground mat, the main powerhouse grounding network, and taps and connections to equipment. The taps from the main ground network to equipment may be shown conveniently on the power and control conduit plans. Details should include test stations if used, water seals, exposed ground bus supports, and typical connections to the frame or housing of plant equipment and metal structures.

m. Conduit and cable tray systems.

(1) Conduit plans for station service power and for all control circuits, including the communication system, should show the conduits in the floor and walls of the designated area. Obstructions, structural features, and locations of equipment influencing conduit location should be shown on the drawings.

(2) Conduits should be in accordance with the legend. Each conduit should be labeled with the size and conduit number shown in the conduit and cable schedule. Conduit termination locations should be dimensioned to building control lines wherever possible.

(3) All outlet boxes and cabinets should be shown on the drawings with size, location, and, if applicable, designation numbers given. Any required boxes should be located and detailed.

(4) Where a number of conduits stub out of a wall or floor within a small area, a structural steel terminal plate should be detailed for use in holding the conduits rigidly in place during concrete placement operations. If conduit locations are not known when the drawings are prepared, indication should be made that dimensions will be furnished at a later date.

(5) Sufficient elevations and details of conduits entering junction boxes, pull boxes, or cabinets should be provided showing the complexity of the work and the quality and size of allowable electrical construction materials. Where stubs are left in concrete walls or ceilings for exposed runs to equipment, the conduit should be stubbed flush with a coupling and closed with a pipe plug.

(6) One or two spare conduits should be run from each motor control center or lighting panel wall location to 6 in. below the ceiling of the room in which the installation is located and terminated in a flush coupling. One or more spare conduits should be similarly terminated in the room below the installation.

(7) Pull boxes, embedded power cabinets, and junction boxes should be completely detailed to show size, material, flange width, front covers, and conduit drilling. For cast iron boxes, a standard catalog product with drilled and tapped conduit entrances is specified.

(8) Drawings should show the arrangement and location of the complete tray system. Details of tray hangers, supports and splices, and supporting blocks for cables entering or leaving the trays, should be shown on the drawings. The trays should be suitably identified for listing in cable schedule references. Construction details of all fabricated components should be provided on the drawing. Component totals should be included on a bill of materials.

n. Wire and cable. The cable and conduit schedule should be prepared as outlined in Chapter 15. It is convenient to list the multiconductor control cables separately from power cables. Computer-generated spreadsheets are generally used for listing all power plant power, control, and communications cables. The locations of wire and cable in trays should be shown on tray diagrams. These diagrams will expedite construction and provide “as constructed” engineering documentation useful for plant maintenance.